

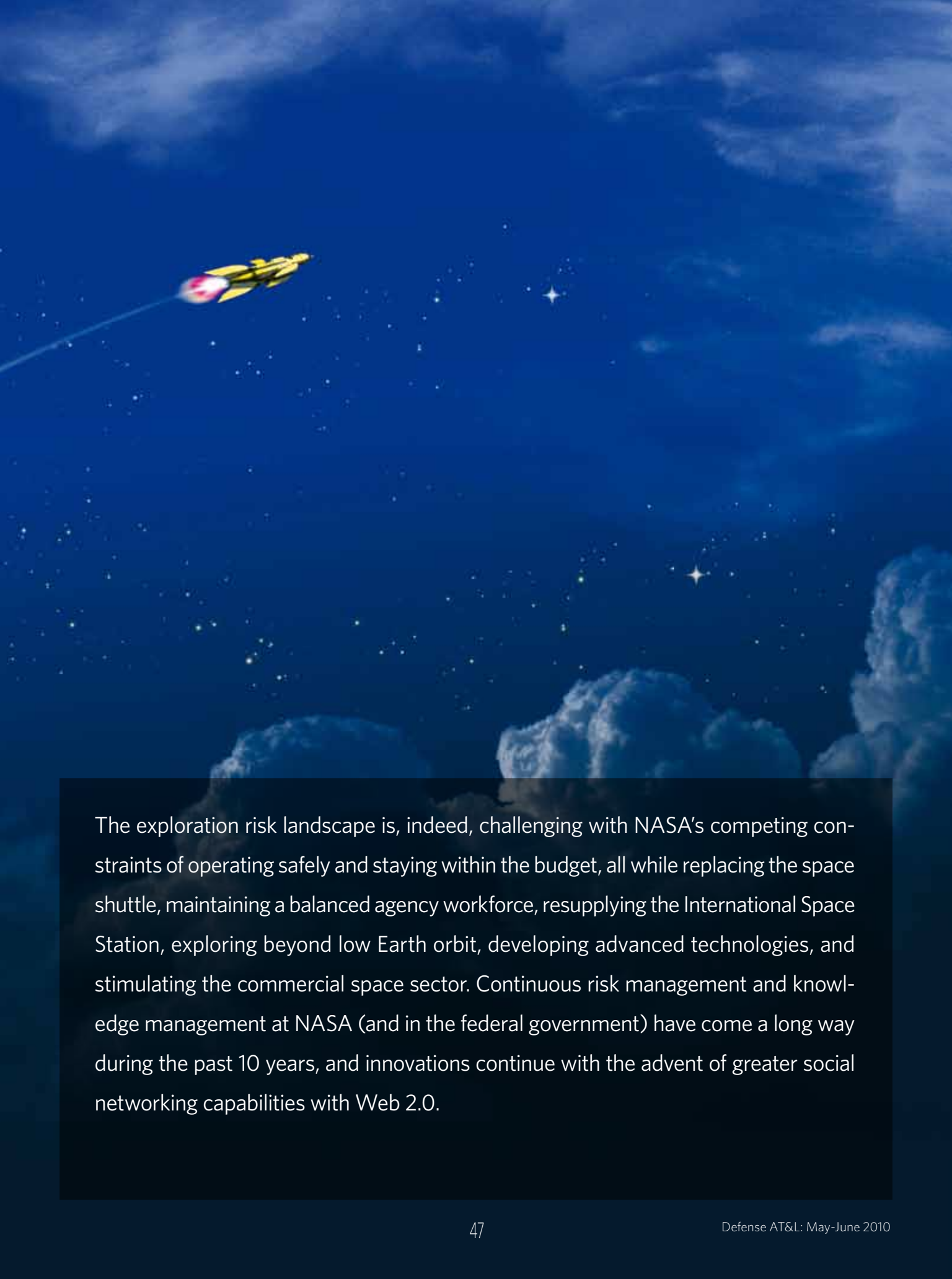
Managing Risk on the Final Frontier

Risk and Knowledge Management
Combine to Support the Work of
Rocket Science

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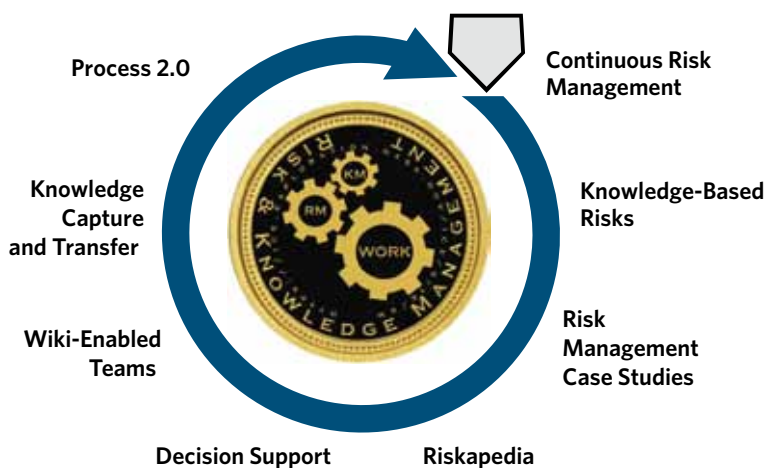
The National Aeronautics and Space Administration (NASA), Exploration Systems Mission Directorate (ESMD) has combined a continuous risk management (CRM) discipline with innovative knowledge management practices to more effectively enable problem identification and problem solving in the complex world of rocket science. The integrated approach also serves as a way to implement lasting improvement in processes used to accomplish work tasks.

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The exploration risk landscape is, indeed, challenging with NASA's competing constraints of operating safely and staying within the budget, all while replacing the space shuttle, maintaining a balanced agency workforce, resupplying the International Space Station, exploring beyond low Earth orbit, developing advanced technologies, and stimulating the commercial space sector. Continuous risk management and knowledge management at NASA (and in the federal government) have come a long way during the past 10 years, and innovations continue with the advent of greater social networking capabilities with Web 2.0.

Figure 1. IRKM Elements



The Integrated Risk and Knowledge Management System

ESMD's Integrated Risk and Knowledge Management (IRKM) System was initiated in 2006. The foundation of the system is CRM, a technical management process that is part of the systems engineering discipline. CRM requires an iterative evaluation of events that could prevent you from meeting your objectives coupled with proactive implementation of measures to control or mitigate those risks. An important and novel aspect of the IRKM approach is using risk records resulting from the CRM process to initiate an assessment of what knowledge to transfer to risk owners to help them solve their problem, then following up to capture the actual strategy or measures used to mitigate the risk. Risk records used in this fashion provide a "cueing function" similar to an aircraft sensor cueing a weapons system sensor. In the IRKM System, CRM informs knowledge management, and knowledge management becomes the enabler of CRM.

ESMD uses an enterprise risk management approach and a common framework for identifying, analyzing, communicating, and managing risks for the directorate and its performing organizations.

The second key concept of the IRKM System is work process improvement. Knowledge management (KM) practices enable ESMD programs to effectively reflect on process performance and provide a structure for process optimization. Risk finds a breeding ground in less-than-adequate process performance whether they are business, engineering, or technical management-oriented processes. To address those risks head-on requires using one or more KM practices or interventions. KM enhances the risk management process, which then helps personnel work more effectively. Hence, the interlocking concepts of risk management—work process optimization and knowledge management—are tightly coupled and mutually supportive. The following paragraphs provide a quick look at key elements of the system. As shown in Figure 1, the IRKM process flows from the domain of continuous risk management (home plate) and notionally moves around the bases.

Continuous Risk Management

CRM is an iterative process that identifies, analyzes, plans, tracks, controls, communicates, and documents risk through all life cycle phases of an organization's product developments. ESMD uses an enterprise risk management approach and a common framework for identifying, analyzing, communicating, and managing risks for the directorate and its performing organizations. Risks are communicated vertically through a well-defined escalation process, while horizontal integration occurs through a multi-tiered risk management working group and board structure. This network of risk managers is also used to communicate lessons learned and best practices—referred to as a "central nervous system" for information flow that is critical for knowledge sharing. Establishing a robust CRM process must be accomplished first as it provides the foundation of the entire IRKM system.

Knowledge-Based Risks

ESMD risk records provide the context for knowledge-based risks—Web-based, multi-media knowledge bundles that provide users with expert advice on risk control and mitigation strategies for specific technical risks. ESMD defines a knowledge-based risk as a risk record, with associated knowledge artifacts, that provides a storytelling narrative of how the risk was mitigated and what worked or did not work. A knowledge-based risk is also a means of transferring knowledge within the CRM process. As key risks are mitigated, particularly risks that are likely to recur across other programs in ESMD, knowledge is captured and transferred. Knowledge-based risks identify the effectiveness of mitigation activities, specifically in terms of cost, schedule, and technical performance. Instead of a "collect, store, and ignore" approach, knowledge-based risks form an active collection of lessons learned that are continually reused and updated.

Examples of knowledge-based topics seen in NASA include composite overwrap pressure vessels (lightweight storage vessels that require careful handling and are a potential hazard); nutation time constant (sloshing propellant during coast phase of launch); tin whiskers (metallic crystal growth on circuit boards); and EVA gloves (damage to spacesuit gloves during extra-vehicular activity).

Riskapedia

The Riskapedia wiki space is intended to assist ESMD programs, projects, managers, and workers in implementing life cycle risk management practices and discipline. Riskapedia provides extensive content (tools, techniques, best practices, videos, and lessons learned) addressing the fundamental “blocking and tackling skills” of risk management: risk identification, risk assessment, and risk control and mitigation planning. The resource is a “hard hat area” that is intended to be under construction for life. The space has been populated with expert-developed content that is intended to evolve over time as users and contributing editors engage in ongoing construction of subject matter articles. Riskapedia is all about user interaction, conversation, evolution, and, ultimately, the accomplishment of work. Users have the opportunity to rate and discuss content, provide or author content (as a contributing editor), ask questions of experts, and use content in the performance of work and the management of risks.

Riskapedia is divided into several sections. The Risk Identification section provides convenient checklists for identifying typical system, programmatic, and integration risks. The Risk Assessment section contains qualitative and quantitative tools and methodologies for analyzing, understanding, and communicating risks. Lastly, the Control and Mitigation section provides expert knowledge and guidance for mitigating and controlling risk in specific areas—and this section is structured very much like the Defense Acquisition University’s ACQuipedia toolkit.

Risk Management Case Studies

ESMD risk records illuminate top engineering management and technical issues. Risk management case studies provide training and insight into how similar problems have been addressed in past NASA programs. Each case is structured to highlight key transferrable aspects of risk management. Transferrable principles include risk identification, evaluation, and mitigation planning. The proper application of risk management principles can help manage life cycle costs, development schedules, and technical scope, resulting in safer and more reliable systems for NASA’s future programs. Our first case study addressed the Space Shuttle Program’s Super Lightweight Tank development. Two follow-on cases now in development examine test and verification management approaches employed on the International Space Station and Space Shuttle Return-to-Flight management and technical challenges. Looking into the future, engineers will face similar risks. Examining the critical thinking that made

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past programs successful will hopefully enhance the technical curiosity of engineers developing future space systems and make their programs equally robust.

Process 2.0

The IRKM System also has an important work-process-assist element called Process 2.0, or P2.0, which is in part modeled on the U.S. Army after-action review process. P2.0s are process-focused, collegial, structured reflection events. There has been huge demand for the P2.0 events, which assist teams in examining all aspects of a given process, including stakeholders, inputs, outputs, and products. P2.0 events use critical process mapping, structured brainstorming techniques, and process failure modes and effects analysis to identify and address work process issues. As an option, P2.0 users can take advantage of a Web-based collaboration tool suite—also used by DAU to support various projects. The tool provides a simple-to-use information capture capability that increases the volume and speed of idea capture and also supports alternative analysis. Most important, the P2.0 method demands and enforces disciplined thinking to drive out actionable process improvements for the team. P2.0s have been used to assist a diverse set of team processes ranging from vibro-acoustic coupled-loads analysis, to the agency independent assessment processes, to a simple integration meeting gone awry. In every case, the result has been rapid, transparent, team-authored process improvement.

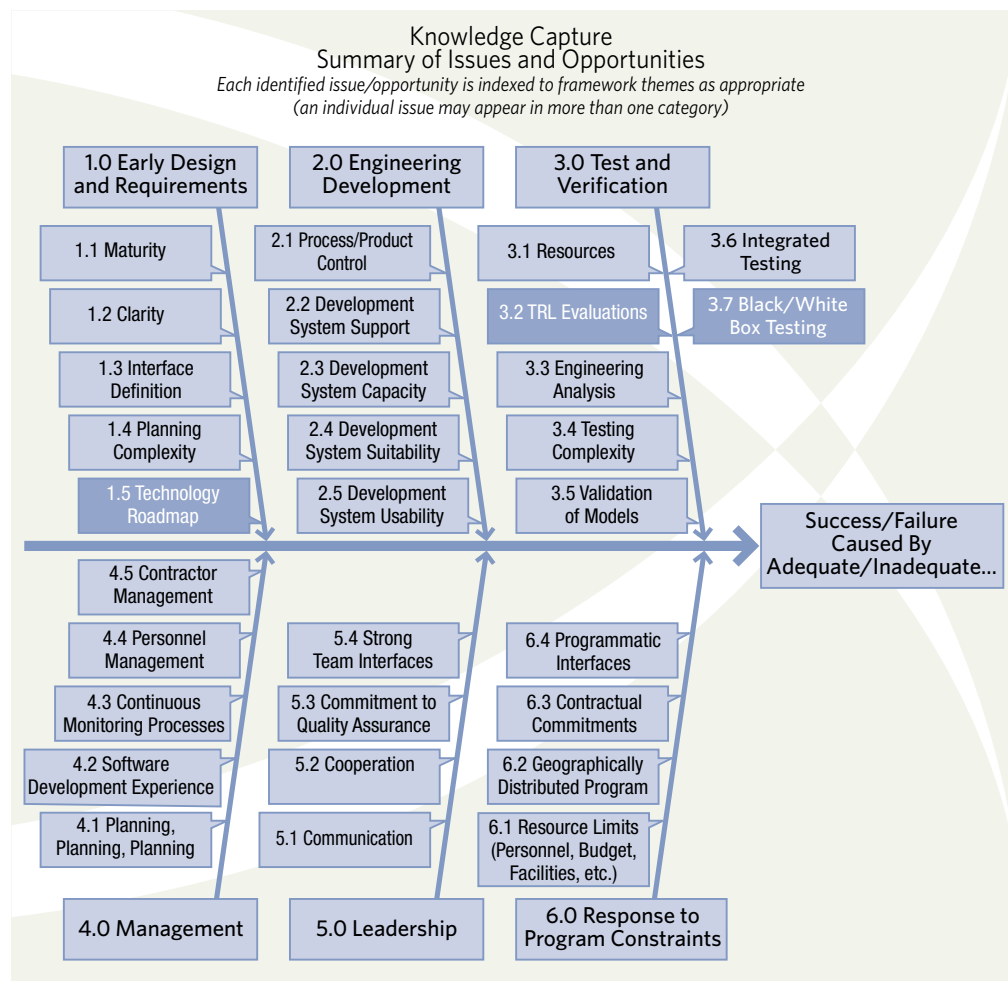
Knowledge Capture and Transfer

Knowledge capture and transfer activities are designed to document project execution lessons learned and best practices in a contextual manner using a conversation-based format. While overlapping in some respects, knowledge capture and transfer differs from P2.0 in that it focuses on project execution rather than recurrent process implementation. Knowledge capture and transfer is an abrupt departure from the notion of lessons-learned databases that often have been hard to use, typically fragment the story, and most regrettably, lack context. Knowledge capture and transfer also rejects the notion of asking participants to fill out questionnaires—something no one enjoys doing. Rather, knowledge capture

and transfer uses the most natural modality—conversation, but carefully structured and controlled conversation. Project risk records are used to guide the initial interviews. A thematic framework is evolved to identify key issue areas and communicate them in an issue/opportunity fishbone diagram similar to that shown in Figure 2.

Wiki implementation is supported by rapid business process analysis to assist in developing the team charter, identifying stakeholder membership, and refining the knowledge architecture. The wiki provides teams an easy-to-use, flexible interface to collaborate on documents, conduct discussions, manage calendars, locate information, and, most important, work more effectively.

Figure 2. Aggregation of Issues/Opportunities for Improvement



Individual issues are synopsized and aggregated, and a composite analysis is provided. Results are rapidly provided to stakeholders using a variety of communication modes, including briefings, design review checklists, peer assists, knowledge cafes (small group brainstorming), and video interviews. An edited report is also developed as an archive and made available electronically to management.

Wiki-Enabled Teams

The ESMD wiki environment enables horizontal communication, collaboration, and knowledge sharing across the ESMD directorate. More than 350 wikis provide a multi-functional tool-set to assist ESMD teams in accomplishing work. An important part of exploiting the wiki technology has been helping teams critically examine their work processes and information architecture, which is then mapped into the tool.

Decision Support

Decision-support services include training teams in developing decision data packages (e.g., rationale, cost and schedule risk analysis, tradeoff analysis, and other supporting documentation) necessary to conduct formal analysis of alternatives and/or successfully meet the requirements of milestone reviews and/or decision forums (boards and panels). In addition, decision-support activities include training and mentoring in specific tools and methods to aid the decision process, including uncertainty modeling, expert elicitation, analytical hierarchy process, and other methods similar to those contained in DAU's Program Managers e-Tool Kit. Finally, ESMD is developing a cadre of trained facilitators to assist teams in using Web-based decision-support technology to support team brainstorming, prioritization, and alternative analysis.

Applicability to Other Organizations

The IRKM System continues to evolve and innovate to facilitate integration, collaboration, and effective work-process implementation across the complex and evolving ESMD enterprise. The fundamental concepts and approach have been broadly scalable within ESMD's diverse work processes (e.g., budget analysis, design and systems engineering, operations planning) and, indeed, could be applied across (or within) any government, commercial, or academic enterprise.

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